SEPTEMBER 19, 1983

CHEMICAL & ENGINEERING NEWS

Suicide substrates: powerful enzyme inhibitors
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Industrial Gases

Recovery brings new reality

A Key Chemicals Review Page 9

Cover: Airco's carbon dioxide plant at Augusta, Ga.

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CHEMICAL & ENGINEERING
NEWS
SEPTEMBER 19, 1983

News of the Week

■ **Droughts and low acreage use spelled losses for fertilizer and pesticide makers but 1984 looks promising.** **Page 6**

■ **NSB commission recommends plan to improve education in math and science.** **Page 7**

■ **President's proposed bill allows joint R&D ventures without fear of antitrust suits, protects patent holders.** **Page 7**

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Postrecession effect on industrial gases is a boost for nitrogen but low demand for carbon dioxide and oxygen. **Page 9**

International

IUPAC to allow individual chemists to become members, under its Affiliate Membership Program, through their societies. **Page 14**

Government

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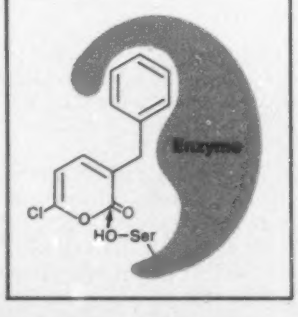


Special Report

Suicide enzyme inactivators aid in studying functions of enzymes, may be important in the development of new drugs. **Page 48**

Industrial Gases Recovery from Recession Is Mixed

Nitrogen demand is up again, but oxygen use continues to lag and carbon dioxide is mired in supply problems; long-term growth has slowed

Bruce F. Greek, C&EN Houston

After a very long period as one of the U.S. chemical industry's best growth areas, industrial gases producers are finding that even they aren't immune to recessions or reduced long-term growth. The latest recession significantly slowed production and chopped forecasts for future growth by half or more.

Throughout the 1970s, industrial gases output grew at 10% or more annually. Plant expansions came at a torrid clip, unfortunately more than production growth. Enter the 1980s; production suddenly changed, but plant construction didn't. The classic result is that combined production of oxygen, nitrogen, and carbon dioxide—the major gases whose immediate market outlooks appear on the following pages—is heading into about 5% annual growth through most of the 1980s, and overcapacity has found a new home.

Plant expansions are continuing, although at not nearly the rate of two years ago. Net capacity additions could be well down as producers close old plants where demand is off and electric power costs are up. In general, newer plants are much more efficient than plants built even five years ago, industry analysts say. The new plants are fully computerized to reduce power consumption and other costs, such as labor. Distribution methods for the truck-based merchant part of the industrial gases market also have been computerized as much as possible to reduce their rapidly increasing costs.

Key Chemicals

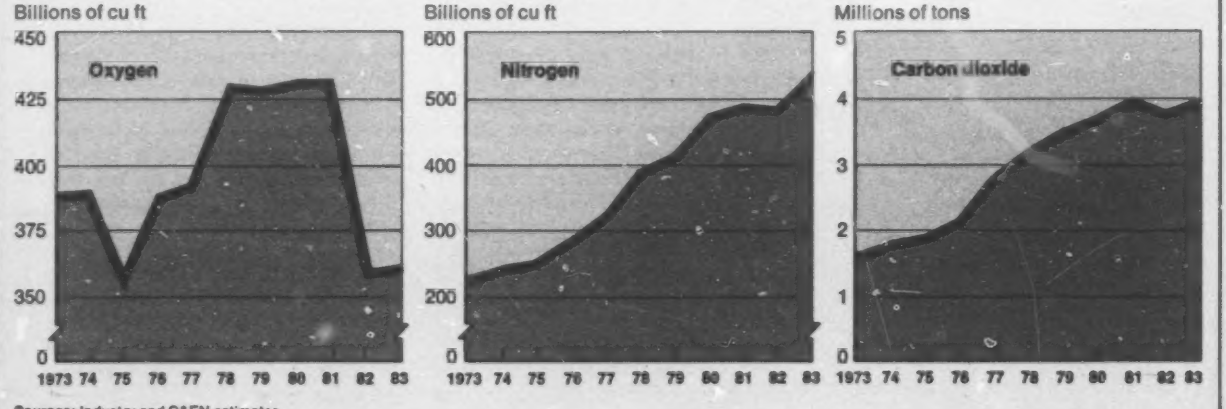
Overall nitrogen and carbon dioxide demand will continue to grow more rapidly than will demand for oxygen, which is becoming the industry's poor cousin.

Nitrogen has an advantage in that many diverse uses developed for it over the past 20 years, buffering it from general economic downturns. New developments still are coming, for example use in the steel industry to shroud processes.

Nitrogen's coproduct, oxygen, in contrast has one major use in metals which takes nearly two thirds of production. Metals' dominance will ease only a little over the next five years. Efforts to find new uses, mainly in the area of atmosphere enrichment, will help somewhat but probably will not overcome the decline in use in basic oxygen furnaces making steel.

Like both oxygen and nitrogen, carbon dioxide is a coproduct, but in an entirely different way. It is tied heavily to ammonia production, the source of 60% of it. Another 30% or so comes from oil refineries. Carbon dioxide production currently is held down by poor demand in its coproducts' other markets.

Carbon dioxide and nitrogen regain growth track, but oxygen lags



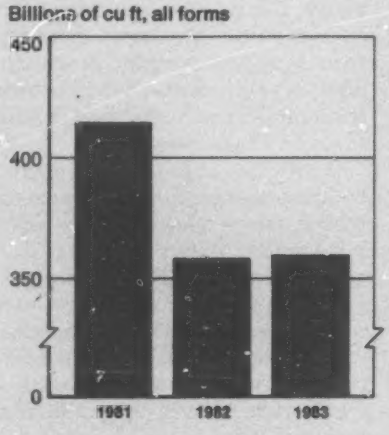
Sources: Industry and C&EN estimates

O_2

Oxygen

- ***Demand still low***
- ***Capacity increasing***
- ***Prices discounted***

PRODUCTION



HOW MADE

Separated from air at low temperatures

MAJOR END USES

Primary metals manufacturing 30%, metals fabricating 35%, health services 15%

FOREIGN TRADE

Negligible

PRICES

49 cents per 100 cu ft plus shipping and equipment charges (merchant)

COMMERCIAL VALUE

$425 million for production, 1983

Oxygen differs from the other big-volume industrial gases, nitrogen and carbon dioxide, in that one major industry dominates demand—metal making and fabricating. And alas, a big part of metal demand is in the woebegone steel business. So it is oxygen's fate that steel's problems have brought its former robust growth to a halt.

Since steel now is in partial recovery from its deep slump from the second half of 1982, oxygen also has begun to recover. Oxygen demand is expected to move up enough from its depths of last winter to about match 1982 demand of 358 billion cu ft. Most industry sources call the 1983 total within a few billion cubic feet of the 1982 figure, although one optimist predicts an increase of 3% to 370 billion cu ft.

Even a 3% upturn isn't much comfort for producers who absorbed a 17% production drop last year from 431 billion cu ft in 1981. The 1983 upturn then isn't doing much to improve plant use rates or pick up coverage of overhead and capital costs. It will be quite some time before the 1981 oxygen production level is regained unless steel goes into a much stronger than expected recovery.

Estimates of current average operating levels of air separation plants range between 60 and 65% of the nameplate capacity, or 70 to 77% of effective capacity. The usual operating procedure for plants with demand for product well under effective capacity is to fill the plant storage tanks and then shut down until more product is needed. Such a scheme cuts overall energy costs compared to continuous operation of the plant at lower fractions of capacity.

So estimates of operating rates include these oxygen plants currently shut down. This is the case, for example, at steel complexes whose basic oxygen furnaces also are down. In other cases, a new, more efficient air separation plant may be close enough to the user that shipping costs are still worth it compared to costs of an old onsite plant. As a result, the old plant is put on standby until demand rises enough to justify restarting it.

These "tonnage" oxygen plants, usually located close to customers with a pipeline connection, fill about 80% of oxygen demand. The remainder generally is served by "merchant" oxygen plants, with product delivered in liquid form by truck to a variety of smaller users.

The distinction between "tonnage" and "merchant" is a bit blurred: Some merchant oxygen users actually have pipeline connections and some small users have mini onsite air separation plants.

Current overcapacity in oxygen keeps downward pressure on prices even though plants' energy costs continue to rise. List prices have stayed flat, although some of the widespread discounting is being reduced.

Tonnage oxygen plants tied to a single, large-volume user have take-or-pay contracts, some of which are old and don't return enough to justify the investment. Contract renewals on these plants are proving difficult to negotiate in view of uncertainties in the steel industry and growing competition among oxygen producers.

Nonmetal outlets for oxygen are many and varied, with health services, chemical manufacturing (ethylene oxide, for example), and enrichment of high-temperature atmospheres being the largest. Growth in demand in these and other uses is not expected to be high this year, partly because of customers' efforts to reduce costs and partly from the lingering effects of the 1982 recession. Because of their relatively small size, none of the nonmetal uses will have much effect on overall oxygen demand in the next few years. However, their share of total oxygen consumption could increase if demand for oxygen in steel stays low.

These other uses of oxygen are almost entirely merchant sales of the gas, generally small in volume and variable in demand. As a result, estimates of the quantities going into these applications are rough at best. Health services probably accounts for a bit less than 15% of merchant oxygen consumption, perhaps 10 billion cu ft per year, according to industry sources.

Saddled with such conditions of limited growth, overcapacity, and low profitability, oxygen is not the hot product it used to be. It clearly is no longer the main reason for building most air separation plants.

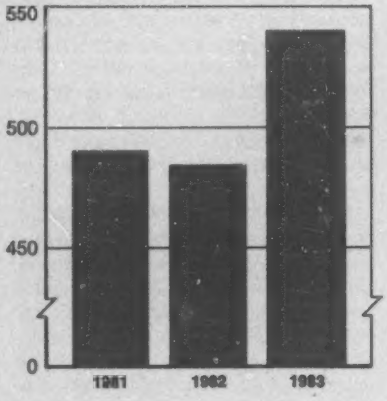
N_2

Nitrogen

- ***Demand rebounding***
- ***Capacity to grow***
- ***Prices up a bit***

PRODUCTION

Billions of cu ft, all forms



HOW MADE

Separated from air at low temperatures

MAJOR END USES

Blanketing atmospheres for chemical processing 25%, electronics manufacturing 15%, enhanced oil recovery 15%, metals treating and processing 15%, aerospace 5%, meat and poultry freezing 5%

FOREIGN TRADE

Negligible

PRICES

Merchant sales 44 cents per 100 cu ft plus shipping and equipment charges

COMMERCIAL VALUE

$500 million for production, 1983

Nitrogen experienced a slight break in its long-term high growth in 1982, but it should easily get back on track in 1983. This rebound will keep nitrogen volume well ahead of oxygen from now on, unless by some remote chance a big new use for oxygen should develop.

Nitrogen appears to have developed its own big new use over the past few years—enhanced oil recovery (EOR) to boost output from old oilfields. This use now will take 15% of all nitrogen consumed in the U.S. this year, up from next to nothing only five years ago.

EOR accounts for a lot of nitrogen's forecast production gain for 1983—as much as 12% over 1982 to reach a total of 540 billion cubic feet and possibly more. Production in 1982 of 484 billion cu ft was off 1% from 1981 as user industries staggered under the recession.

Plant capacity for nitrogen is an elusive figure because demand varies greatly with location. In some cases little, if any, nitrogen is sold from an air separation plant because the plant's primary purpose is to produce coproduct oxygen. At other locations—for example, in an oilfield for EOR—oxygen actually is discarded because the plant is too far from oxygen markets. Hence, in most air separation plants, operation is adjusted over a wide range to produce the two gases in relation to the nearby demand. The gas in lesser demand, more often nitrogen, also is used partly as purge gas to remove unwanted impurities, further complicating capacity estimates.

The merchant market for nitrogen is larger than that for oxygen, accounting for more than 25% of production. This market share varies from year to year as customers shift from buying nitrogen on the outside to either making their own in small air separation plants or connecting to a pipeline.

The diversity of nitrogen markets resulted from producers' efforts over many years to find some way to sell this formerly discarded coproduct of many air separation plants. Oddly, producers succeeded so well that they now have the reverse problem at many plants—looking for new oxygen uses to balance demand for nitrogen.

Blanketing atmospheres in various industrial processes—used to ensure product quality and plant safety—are the largest use of nitrogen, perhaps 25% of the total. This use declined somewhat in last year's recession, but recovery is well under way. However, blanketing is no longer a fast-growing use as it was during the boom in previous decades in chemical and oil refining capacity. Longer-term growth forecasts are now much below the former 7 to 10% annual rates.

EOR is now the fastest growing use of nitrogen but from a small base. EOR nitrogen plants usually are single-use units in oilfields, often far from any industrial area. Their former red-hot growth is settling down now under the dampening influence of the world oversupply of oil, lower oil prices, and lower oil demand. Longer-term, availability of suitable oil-containing formations could become the most important question on EOR use of nitrogen.

The electronic use of nitrogen also seems to be in a slower growth stage. Quality requirements here continue to rise in line with quality requirements for the chips used in circuits. The ultra-high-purity end of this market, though small in volume, commands a steep price. Growth in this area has throttled down to 10 to 20% annually from the former sizzling 30 to 40% rates.

The metals treating and processing use of nitrogen is really another blanketing application. Nitrogen is used in process atmospheres in galvanizing, heat treating, metal drawing, and the like. Quality demands for the finished product are keeping this growth at 7 to 10% a year.

The many other uses of nitrogen also show some high growth rates, although some are well beyond their peak growth years. For example, nitrogen use in quick freezing of red meat, poultry, and specialty food products has slowed way down as a result of the recession and changes in eating habits. None of the small uses of nitrogen are expected to add much more than 1 billion to 2 billion cu ft to total demand in 1983.

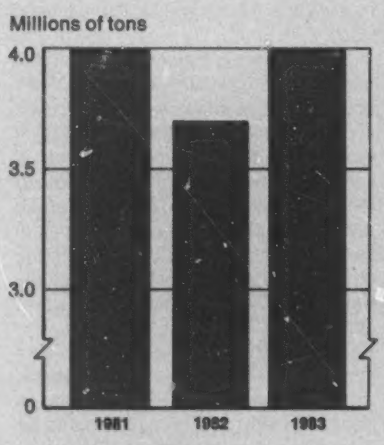
Even so, the combination of gains in some small uses and major gains in large uses has pulled nitrogen demand back to a decent overall growth rate. Prospects indicate a continuation, hampered a bit by the need to find some way to revive coproduct oxygen.

Carbon Dioxide

CO_2

- ***Supply limited***
- ***Some capacity shut***
- ***Prices firmer***

PRODUCTION (nonoilfield)



HOW MADE

Recovered from synthesis gas in ammonia production, from refinery production of hydrogen, from fermentation processes, and from natural wells

MAJOR USES (nonoilfield)

Refrigeration 30%, beverage carbonation 25%, urea manufacture 15%

FOREIGN TRADE

Negligible

PRICES

About $77 per ton for large uses; prices vary by region

COMMERCIAL VALUE (nonoilfield)

$150 million for production, 1983

Carbon dioxide has become an industrial gas with two lives—one in the oilfield and the other everywhere else. Oilfield use, mainly in enhanced oil recovery (EOR), is the larger but isn't reported to the Bureau of the Census. So production data are mainly industry analysts' guesses.

To make the data situation worse, the all-other category for carbon dioxide may well include small amounts used in EOR. Most nonoilfield carbon dioxide is a coproduct with ammonia or refinery hydrogen. Smaller quantities are recovered from fermentation-ethanol processes.

The oilfield side of carbon dioxide is quite different from the gas's traditional merchant and captive markets. Industry analysts estimate that EOR carbon dioxide is now much greater in volume. This carbon dioxide comes almost entirely from natural wells, which contain gas with carbon dioxide content ranging from as little as 10% up to nearly 100%. This carbon dioxide is produced, separated from the other gases, and pipelined to injection wells, where it is put into suitable geologic formations to boost oil output. It in effect acts as a solvent for some of the underground hydrocarbons, causing them to be displaced from the formation structure and flow toward producing wells. Many techniques, using carbon dioxide alone and with other materials, are being either used or investigated in EOR.

Additional smaller quantities of carbon dioxide are used in the oilfield to maintain pressure and to carry other substances whose job it is to keep pores open in the structure to allow the oil and gas to move to a well bore. Often, this carbon dioxide is supplied by merchant producers.

Outside the oilfield, carbon dioxide has a supply problem owing to its major sources in ammonia production and refineries. Both sources have been reeling from the aftereffects of the recession in fuels and the continuing recession in fertilizers. The result is that carbon dioxide production is controlled now by noncarbon dioxide markets. Some plants are shut down; others are running full tilt.

With an eye toward such supply limitations, industry sources expect that 1983 nonoilfield carbon dioxide production will be about 4 million tons, up 8% from 1982's 3.7 million tons. At least, this gain represents full recovery from the 1982 recession. About 60% of this carbon dioxide will come as a coproduct of ammonia production, with nearly another third from refineries.

Estimates of carbon dioxide capacity are completely up in the air, analysts say, because of questions about operability of some plants. If the severe drought and the government's payment-in-kind programs this year cause downstream fertilizer demand to jump in 1984 for increased plantings, then some marginal plants supplying carbon dioxide might be restarted. However, some EOR-carbon dioxide plants might be shut down or moved without general knowledge.

The use pattern in nonoilfield carbon dioxide isn't changing much. However, analysts say, if supply continues limited, causing prices to rise, some refrigeration uses could be taken over by competing nitrogen or even mechanical refrigeration. Higher-priced carbon dioxide might even suffer in use in high-value foods such as red meat, which are quick-frozen with carbon dioxide to preserve quality. There may be a limit here in food processors' willingness to buy aesthetics. Overall, food refrigeration continues to be a good growth area for merchant sales of carbon dioxide.

The second largest merchant use of carbon dioxide is beverage carbonation. The soft drink business is growing not much faster than constant-dollar gross national product. The advent of light beers is beginning to help this use, but the base is still small.

Carbon dioxide's major industrial use, most of it captive, is in making urea. Urea production has benefited over the years from farmers' greater use of solution-type fertilizers, but this year the farm business is so bad urea has suffered too. Urea may recover next year if farm commodity supply tightens and prices rise.

No other uses of carbon dioxide will have much effect on total nonoilfield production. For both merchant and captive producers, the key to output volume and profitability this year is somewhat out of their hands, resting with ammonia plants and oil refineries.